The Johns Hopkins University

Progress Report: Year 1 (5/1/94-4/30/95)
NASA SR&T NAGW-4055

PI: Robert E. Erlandson
JHU/APL

March 20, 1995

Summary of Work Performed: Year 1

The research performed involves the analysis of electromagnetic ion cyclotron (EMIC) waves and the interaction of these waves with thermal plasma. The two primary studies performed during the first year involved the study of EMIC waves on auroral field lines recorded using the Freja satellite [Erlandson et al., 1994] and the study of EMIC waves at sub-auroral latitudes recorded at ionospheric altitudes using the DE-2 satellite [Erlandson, 1995].

A study on the association between electromagnetic waves below the proton gyrofrequency and transversely accelerated oxygen ions was performed using data acquired by the Freja satellite. This study involved comparing data from five different Freja instruments; the magnetic field experiment (F2), the electric field experiment (F1), the hot plasma experiment (F3), the wave experiment (F4), and the electron electrostatic analyzer (F7). The F1, F2, and F3 experiments recorded waves below the proton gyrofrequency (400 Hz) which were ordered by the oxygen and helium gyrofrequencies. These waves, observed both in the electric and magnetic field, were identified as EMIC waves most likely generated by low energy (≈100 eV) electron beams and occurred in a region of inverted-V electron precipitation in the pre-midnight sector. Oxygen ions preferentially accelerated perpendicular to the magnetic field were observed at the same time as these waves below the oxygen and above the helium ion gyrofrequency. It was concluded that these O+ EMIC waves accelerated oxygen ions in the direction perpendicular to the magnetic field.

- The significance of the Freja observations is that it showed that EMIC waves below the local oxygen ion gyrofrequency, presumably generated by ≈100 eV electron beams, preferentially accelerate oxygen ions in the direction transverse to the magnetic field.

The second study performed during the first year of this research was a statistical study of Pc 1 waves (0.2 to 5 Hz) at ionospheric altitudes as observed in DE-2 electric field data. This study was motivated by an earlier study by Erlandson et al. [1993] who found that these ionospheric Pc 1 waves, identified as EMIC waves generated near L=4 in the equatorial magnetosphere, were the source of electron temperature enhancements. It was important to determine the occurrence patterns of these waves as the first step in understanding the occurrence of EMIC wave related electron temperature enhancements.

The DE-2 Pc 1 statistical study identified 469 Pc 1 wave events in ≈900 hours of Vector Electric Field Instrument data. The waves were found to peak in occurrence rate from 54 to 60° invariant latitude (INV) and in the magnetic local time sectors between 0200-0800 hours (dawn sector) and 0900-1600 hours (noon sector). It was found that these waves occurred, on average, 0.8 R_e inside the plasmapause as determined using a K_p based model of the plasmapause [Carpenter and Anderson, 1992]. The source of these waves in the noon sector was identified as EMIC waves generated in the equatorial magnetosphere as the frequency of these waves were between the equatorial oxygen and helium gyrofrequency. The source of waves in the dawn sector was less certain due to a nearly constant frequency verses L-value profile and a low percentage of events which contained a magnetic field component (in addition to the electric field peak upon which the study is based). The occurrence rate of dawn sector events, however, peaked at altitudes from 250-500 km suggesting that these waves had been ducted in the ionosphere. The results of the statistical study were compared with the occurrence of Pc 1 waves observed on the ground. It was concluded from this comparison that the ionospheric Pc 1 waves are most likely what is referred to as structured Pc 1 pulsations in ground based observations. The significance of this study is that:

- a statistical study was performed to determine the occurrence rate of Pc 1 waves at ionospheric altitudes from 250-1000 km. It was found that these waves occur on average 0.8 R_e inside the plasmapause in the dawn and noon sectors. The different properties of these waves in MLT suggest that the effect of these waves on electron temperature enhancements may also differ depending on MLT sector.

A listing of publications and presentations funded fully or partially by this grant are listed below:

Publications: Year 1

Erlandson, R. E., L.J. Zanetti, M. H. Acuna, A. Eriksson, L. Eliasson, M. H. Boehm, L. Blomberg, Freja Observations of Electromagnetic Ion Cyclotron (ELF) Waves and Transverse Oxygen Ion Acceleration on Auroral Field Lines, Geophys. Res. Lett., 21, 1855, 1994.

Erlandson, R. E., A Statistical Study of Pc 1 Waves at Ionospheric Altitudes, J. Geophys. Res., Submitted March 15, 1995.

Presentations: Year 1

Erlandson, R. E., T. L. Aggson, and J. A. Slavin, Initial results from a statistical survey of Pc 1 waves recorded at ionospheric altitudes by DE-2, EOS, Transactions, American Geophysical Union, 75, 302, 1994. (Spring AGU, Baltimore).

Erlandson, R. E., and L. J. Zanetti, Freja Observations of Electromagnetic Ion Cyclotron (ELF) Waves and Transverse O+ Acceleration on Auroral Field Lines, Freja International Science Workshop, 1994.

Erlandson, R. E., L. J. Zanetti, M. H. Acuna, A. Ericksson, L Eliasson, M. H. Boehm, and L. Blomberg, Freja Observations of ELF Waves and Transverse Oxygen Ion Acceleration on Auroral Field Lines, EOS, Transactions, American Geophysical Union, 76, x, 1995. (Spring AGU, Baltimore).

Statement of Work: Year 2 (5/1/95 to 4/30/96)

The tasks to be performed during the second year involve two main activities.

1) We plan to continue investigating the correlation between low frequency waves at sub-auroral latitudes and electron temperature (T_e) enhancements using DE-2 data. The results from the statistical study performed during the first year will be used to guide this investigation in terms of the dependence of T_e enhancements on MLT and other wave properties ($E/\Delta B$) ratios.

2) We plan to extend the investigation of oxygen ion acceleration by EMIC waves on auroral field lines below the oxygen ion gyrofrequency using Freja data. These data will be used to calculate the Poynting flux, wave polarization, and compare the pitch angles distribution of the accelerated oxygen ions with the wave frequency distribution. This will allow us to determine if the altitude at which these ions are accelerated is consistent the wave frequency distribution. The acceleration process is expected to be a resonant process where the oxygen ions are accelerated when the Doppler shifted wave frequency is equal to the oxygen ion gyrofrequency.